Urban transport system benchmarking

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Abstract

This article elaborates on benchmarking as a means to facilitate policy makers during the decision making process aimed at improving urban transport system performances. The proposed benchmark contains five critical success factors: accessibility, cost of transport, safety, environmental pollution and congestion. The benchmark result provides policy-makers with figures that describe the position of each aspect of an urban transport system of a city or region compared with that of other cities or regions. In a case study the proposed benchmarking approach is tested by analyzing the performances of the urban transport systems of the two cities Berlin and Rotterdam. In making policies for urban transport systems, there are many aspects that should be taken into account, not only from government perspective (investment and operational cost), customer perspective (accessibility, safety, congestion and cost of transport), but also from sustainable development perspective (environment). These aspects should be added as additional criteria for the development of a sound transport policy. Aspects that have low performance should be enhanced in the future, while the "best in class" aspects, can be used by regions that perform less. The first results showed that benchmarking urban transport systems can give policy makers an improved insight in the performances in respect to that of other cities and indirect advice on future investments. To be able to use the proposed approach more test-benchmarks are necessary.
Keywords: benchmarking, urban transport planning, transport system performance.

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1 Introduction

The desires of people in an urban area to move create demand for urban transportation. Passenger's preferences in terms of time, money, comfort, convenience and availability have influence on mode choice.

Improvement of urban transport systems can easily be obtained if there are figures that explain the current weaknesses. In order to rectify the weakness, policy-makers need to generate alternatives or ideas to enhance the urban transport system in their region. One of the ways that leads to this insight is by means of benchmarking. The idea behind benchmarking is to continuously study the performance of urban transport systems in other regions. Consequently, the figures can be used as a basis for future plans and policies. Low performances should be improved and "best in class" aspects can be used as a ground basis for improvement in other regions. The research question of this study is: What roll can benchmarking play in providing fundamental information for policy-makers when understanding the performance of urban transport systems.

2 Urban transport benchmarking

By means of benchmarking a set of regions is compared and examined one by one. Benchmarking is a continuous learning process to identify and implement best practices. Transport benchmarking from a policy point of view is a tool to assess the potential for improvements of the transport system and to develop and implement appropriate policies. Benchmarking as a dynamic, continuous and heuristic learning process includes feed back elements to align the approach and its different steps to the objectives and to the availability of information [1].

The critical success factors to measure the performance of an urban transport system are the same as the criteria for making a policy, only the indicator for cost is different. Cost as an indicator is different because the purpose of benchmark is to identify areas for potential change, and cost as such is not. The criteria for benchmarking urban transport systems are:

1 Accessibility
Accessibility cannot be measured by using only that indicator. Other indicators for accessibility in an urban area are needed. These supplementary indicators are:
   - Network accessibility. Presented by the topological structures of the network in a certain urban area, either the network for private vehicles or for the public transport.
   - Space accessibility; Covering public transport stops or stations. Number of stops or stations per km can represent how easily the public transport can be accessed by passengers.
   - Time accessibility; measuring the performance of public transport services. The more frequently a public transport operates, the better the public transport system in the area is.

- Travel speed; the average speed with which a traveler can travel on the network from an entry point to an exit point. Speed is an aspect is an important travelers' preferences aspect.
- Service attributes; Service attributes concerning accessibility include information, either route information or real time information. Route information helps travelers determine their destination route, while real time information can help travelers in making quick decisions.

2 Cost of transport.
It represents not only the travel cost per km using public transport facilities, but also the cost of parking private cars. The investment and operational costs for transport are not included as part of this criterion, because our benchmark concerns only elements that make the region more attractive to the end user of the transport system and does not concern elements involved in funding the region.

3 Safety
The safety criterion can be described in regard to accident and feeling secure. This benchmark study will only discuss safety in terms of accidents, because that is a representative way of reflecting the performance of a transport system as is mentioned in the literature of Modeling Transport [3]. A good transport system should not have many accidents; therefore, the number of accidents per km can be used to measure the safety level of an urban transport system.

4 Pollution
Covers air and noise pollution in the region. Although there is another type of pollution, the discussions concerning pollution in this study will be restricted to air and noise pollution only.
Air Pollution. Emissions from vehicles which cause concern are CO_2, CO, NO_x (oxides of nitrogen), sulphur dioxide (SO_2), HC, lead particles and smoke [2]. According to D. Stead [4], vehicle emissions depend on the journey distance and a number of different operating conditions such as mode, occupancy, vehicle age, fuel type, engine temperature, travel speed and engine size. Emissions are related to the vehicle size and fuel type.
Noise pollution. Surveys carried out in the 1970s by Morton-Williams *et al*. (1978) showed that road traffic was the most common cause of unwanted noise in people's home [4], with heavy good vehicles and motorcycles being the main culprits.

5 Congestion
Congestion will delay the road traffic, and it will cause tardiness. Thus, time lost by the congestion or congestion per km or per hour is the best indicator to measure the congestion level. However, congestion can also be defined as additional time spent on traveling [2].

After determining the indicator measurements for this study, it was found that there is a causal relation between speed and station density. These two criteria could cause duplication. A large number of stations or stops will reduce the vehicle speed. In theory all indicators should be independent (to avoid duplication), the accessibility criterion will be described using both speed and space accessibility sub-criteria. According to Van Nes [5] these two sub-criteria are described as criteria forming the transport service.

Because regions may be quite different a grading system is required which reflects how well each criterion of one region performs compared to another region.

3 How to interpret the results

The result of this transport benchmarking is presented on a spider chart. Each spoke in the net represents a performance criterion, so there are five spokes in the spider chart used. These five spokes are accessibility, safety, environment, cost and congestion.

The performance level is calculated using a grading system. The grading system for this study goes from 0 to 1 (where 0 = poor performance, 1 = best practice). Each criterion is scored from its sub-criteria, and the scoring system is based on binary systems (where 0 = worse, 1 = better). The accessibility criterion is scored from its five sub-criteria: network, time, speed, space and service. If one sub criterion of accessibility, for instance network accessibility in Rotterdam performs better, then the network accessibility in Rotterdam receives the score 1 and the score for Berlin is 0. This scoring process continues until all sub-criteria have been allotted a score. However, there is an artificial region, which does not exist in reality, whose performance is 1 for all criteria and this becomes the "best region".

In a case of benchmarking several regions, all regions will be compared and examined one by one. Nevertheless, to make the comparison easier, each region is compared to the "real-best" region first, but not to the "artificial-best" region. The "artificial-best" region is shown in the spider chart as "best region". This "best region" describes the condition of a region that has the best performance on all indicators. If a region scores lower than the best practice, then it will be compared to the second best practice. If it still scores lower then the comparison keeps on going until he is better than another region. Thus, the current grade of all regions will change simultaneously as a new region enters this comparison system.

Once all the sub-criteria have been correctly scored, the criterion can be measured by dividing the total score of sub-criterion of one region with the total score of sub-criterion of all the regions. The criterion scoring process continues until the five performance criteria have all received their grade. By connecting each criterion node with another, an illustration picture of the transport situation is formed.

$$C_i = \frac{\sum_{r=1}^{x} S_r}{\Sigma S_i}$$

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where

C_i = Criterion i; i= accessibility, safety, environment, cost and congestion
S_r = Sub-criterion of i criterion for one region
S_i = Score of criterion i of all region

The table below contains the summarized data of the urban transport system in Rotterdam and Berlin. The data presented in the benchmark table was obtained after processing raw data for the urban transport system in Rotterdam and Berlin (Widianingsih [6]).

Table 1: Benchmarking data.

Indicator	Rotterdam	Berlin
Accessibility		
1. Network Accessibility		
- Main road	Rectangular	Radial arc
- Metro	Linear	Radial arc-linear
- Bus	Grid-linear	Linear-rectangular
- Tram	Rectangular	Radial arc
2 Time accessibility		
- Metro	Every 8 minutes and no night line	Every 5 minutes and 8 night lines
- Bus	Every 20 minutes and 11 night lines	Every 10 minutes and 13 night lines
- Tram	Every 15 minutes and no night line	Every 10 minutes and no night line
3. Travel Speed		
- Public transport	Morning : 26 km/hour Off peak hours : 27 km/hour Evening : 25 km/hour	
- Private cars	Morning : 39 km/hour Off peak hours : 44 km/hour Evening : 40 km/hour	
4 Space accessibility		
- Station density	1331/602,03 = 2,21 stops/km^2	0,291 stops/km^2
Average public transport stops density		
a. Metro	44/602,03 = 0,07 stops/km^2	
b. Bus	1005/602,03 = 1,67 stops/km^2	
c. Tram	282/6022,03 = 0,47 stops/km^2	
5. Service attribute		
- Route information	- No route information in the bus, only in metro and in the tram.	- There is route information in bus, metro and tram
- Real time information	- There is real time information in every metro station, which: ♦ Gives information about the metro destination	- There is real time information in every metro station, which ♦ Gives information about metro destination ♦ Informs how long the passenger has to wait for the next metro
Safety		
- Road accident ratio	3603/9665,2 = 0,37 accident/million km	142166/7563165) = 0,002 acc/mil. km

Table 1: Continued.

Indicator	Rotterdam	Berlin
Environment		
- Air pollution - NO_x emission - CO_2 emission - HC emission - CO_x emission - Noise pollution >59DB(A) >60DB(A)	9400000000/(0,467*966520000) = 2,08 gram/km 150800000/(0,467*966520000) = 0,33 gram/km 400000000/(0,467*966520000) = 0,88 gram/km 19786/602,03 = 32,86 houses/km^2 13025/602,03 = 21,63 houses/km^2	30200E6/(0,37*7563165E6) =0,011 gram/km 155700E9/(0,37*7563165E6) = 0,0556 gram/km 312000/891 = 350 houses/km^2 236000/891 = 264,87 houses/km^2
Cost		
1. Travel cost - Hourly-ticket - Daily-ticket - Weekly-ticket ***2. Taxi*** ***3. Parking fares***	3/25 = 0,12 Fl /km 12/(24*25) = 0,02 Fl/km 18/(7*24*25) = 0,0043 Fl/km Fl.3,40 per km Min f 2,2 and Max f5 But more than 70% the parking fares cost around f2,2 and f3,3 per hour.	3,9/(2*50) = 0,078 DM/km 7,8/(24850) = 0,013 DM/km 40/(7*24*25) = 0,0095 DM/km DM 3 per km Between DM 2,- and DM 4,- per hour
Congestion - Traffic work congestion - Traffic accident congestion	28,8 hours/million-km 0,063 hours/million-km	Not available

After calculating all the criteria that reflect the performance of the urban transport system for both regions, they are displayed in a spider chart. The criteria for missing data are assumed to be equal. The spider chart in figure 1 includes a region called “Best Region” is the “artificial-best region”. Urban transport planners and policy makers should support this analysis with some analyzes and suggestions concerning the good and bad performances.

Table 2: Results of urban transport benchmark Rotterdam-Berlin.

Criteria	Rotterdam	Berlin	“Best Region”
Accessibility	0,3	0,7	1
Safety	0	1	1
Pollution	0,667	0,33	1
Cost	0,4	0,6	1
Congestion	0	0	1

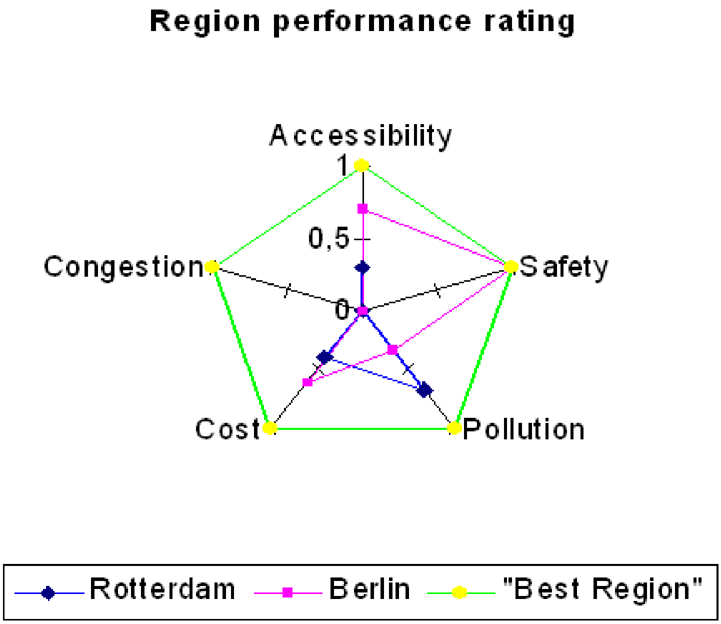

Figure 1: Benchmark result.

After completing the benchmark process for Berlin and Rotterdam in the field of urban transport, it can be concluded that for all performance criteria except pollution and congestion (where the data for Berlin was not available), Berlin performs better than Rotterdam. However, Berlin does not always perform the best (scores 1) in every criterion, because each criterion is built up from several sub-criterion that have to be scored for both region. The higher the score possessed by a region, the better the performance based on that criterion. Therefore, if Rotterdam scores 0,667 and Berlin scores 0,33 for the criterion pollution then it means that Rotterdam has a lower level of pollution or a higher quality level of environment (fewer areas are polluted in Rotterdam than in Berlin). Therefore, the result of having sub-criteria is that the best practice becomes the “better practice”. Nevertheless, Berlin is the best practice according to the safety criterion, because that indicator consists of one criterion only. To decide on criteria to improve other criterions should be considered.

4 Results, shortcomings, conclusions and recommendations

4.1 Results

Benchmarking can be used as an information data base of transport performance of cities world wide. Every city can enhance its performance by gathering idea from other cities, which are already in this database. Nevertheless, one thing should be remembered that not all policies of other cities are fitted in other cities.

To determine if a transport policy is good enough for an urban area or not, an assessment that assessing the alternatives and impacts of the urban transport system should be developed. *Dialog* in this system allows users to make corrections, additions, and deletions quickly and easily as well as performing numerous 'what-if' analyses by changing some values and observing the results.

4.2 Shortcoming of the study

Since this study only consists of two cities, thus it will be a good idea to expand the benchmark study with more additional partners, so the results will be even more convincing. This study does not give information on aspect of urban transport system as such, for example, this study does not explain how to deal with investment and operational cost. Besides, this study does not include the urban spatial structure also, so another type of area in a region. This study also did not look into organizational structure and culture and its role in decision making.

4.3 Conclusions and recommendations

Data concerning the current performance of the current urban transport can not provide policy makers with strong alternative suggestion, because it does not have fundamental standard performance. Consequently, benchmarking is an appropriate method for this issue. Although benchmark is almost the same as multi-criteria comparative analysis, the continuity study of a benchmark is the strongest point of this method. Always keep the eyes open to other will make the policy makers aware of what are lacked and bad in their region.

In deciding what policies are the best for a region, many aspects should be taken into account. Not only from customers' perspective, but the policies should also enhance the region into a more sustainable area. As is mentioned that this study is discussing transport services in respond to the growth of a region, while, transport services can also incite the growth of a region.

In making policies for transport system in urban area, there are many aspects to be taken into account, not only from government perspective (investment and operational cost), customer perspective (accessibility, safety, congestion and cost of transport), but also from sustainable development perspective (environment). However, this study is partial elements of urban transport system beside the management of the urban transport system, the organizational structure of urban transport system and the local political and authorities in designing the urban transport policies. Moreover, these are several issues that should be dealt when extending the model to make it more representative of the real-world situation in dealing with urban transport system.

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